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VERIFICATION OF TRANSLATION

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I verify that the attached English translation is a true and correct translation made by me of the attached specification in the German language of International Application PCT/EP03/05811;

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Apparatus for handling rotor blades

The invention concerns an apparatus for handling rotor blades of wind power installations.

For the assembly of wind power installations inter alia the rotor hub and the rotor blades are transported to the building site individually, because of their considerable dimensions. At the site they are then assembled to form a rotor unit.

Various assembly procedures are considered for that purpose. In one procedure the rotor blades are mounted to the rotor hub on the ground and the entire rotor unit is then conveyed into the assembly position and fitted there, by a crane.

In another procedure the rotor hub is firstly mounted to the head of the wind power installation. Thereafter the rotor blades are lifted individually to the rotor hub and there assembled in situ.

In both cases however it is necessary to handle the large rotor blades weighing several tons, move them precisely into the respective installation situation and hold them there.

That is implemented by a crane which lifts the rotor blade with straps (or chains), moves it into its installation situation and holds it there. For that purpose the straps are laid around the rotor blade at predetermined positions. The rotor blade is then lifted and transported.

The object of the invention is to provide an apparatus for the simplified handling of a rotor blade.

In an apparatus of the kind set forth in the opening part of this specification that object is attained by a rigid carrier element with at least one rotor blade receiving means fixedly connected thereto.

In that respect, the invention is based on the realisation that, in the case of a rotor blade which is received in the apparatus according to the invention, in particular the effect of wind during the blade-fitting procedure

on the one hand and the effect of mass inertia on the other hand are reduced.

A ball rotary joint arranged on the carrier element permits a rotary movement of the apparatus with the rotor blade in a defined rotary plane. In order to be able to perform such a rotary movement by machine, a rotary mechanism drive can be provided at the ball rotary joint.

Eyes can be provided at mutual spacings for various tasks, such as for example fixing securing cables and/or guide cables. Guide cables make it possible to provide manually for example for orientation of the rotor blade in the event of failure of or in place of the rotary mechanism drive, from the ground.

In order to embody a particularly simple receiving configuration for the rotor blades, the rotor blade receiving means can be in the form of a frame which encloses the rotor blade at at least three sides.

In accordance with a development of the invention a locking member is mounted pivotably at one side of the rotor blade receiving means. That locking member permits the rotor blade receiving means to be closed at the fourth side so that the rotor blade is reliably prevented from unintentionally sliding out of the rotor blade receiving means.

In order to guarantee that the rotor blade is held securely in the rotor blade receiving means, in a preferred development of the invention the rotor blade receiving means embraces the rotor blade in positively locking relationship.

In a particularly preferred feature the rotor blade receiving means is of such a configuration that cushions are provided between the rotor blade receiving means and the rotor blade in order to avoid damage to the rotor blade.

In a particularly preferred feature those cushions are inflatable. In that way the rotor blade can be accommodated in the rotor blade receiving means when the cushions are initially uninflated. As soon as the rotor blade is in the predetermined position the cushions are inflated with a predeterminable pressure. In that way on the one hand the rotor blade is

fixed in the desired position while on the other hand damage to the rotor blade is reliably prevented.

In order to be able to transport a rotor blade with the apparatus according to the invention, in a particularly preferred feature that apparatus is of such a further configuration that there are provided valves for filling and/or emptying the inflatable cushions. There are also provided an energy storage means and/or a pressure storage means and/or at least one plug connector for the connection of an electric and/or hydraulic and/or pneumatic line. That configuration of the apparatus according to the invention means that the inflatable cushions as well as the energy storage means and the pressure storage means can be filled. They can then be separated from the lines and permit the apparatus to be transported with the rotor blade, in which case any pressure losses which may occur in the cushions can be compensated by the storage means. The energy storage means, for example a capacitor of suitable size or a chemical storage means such as an accumulator provide in that situation the required energy for a control system and for the actuation of suitable control devices such as valves. It will be appreciated that in that respect suitable sensors are also included.

In an alternative embodiment of the invention the apparatus includes at least one carrier bar and a carrier plate, wherein the carrier bar engages through a through opening provided in the rotor blade and ends at the carrier plate. That arrangement provides that the carrier plate forms the contact surface for the rotor blade and can be of a suitably large dimension and suitably cushioned. The carrier bar extends through the rotor blade and thus makes a fixed connection between the carrier device and the rotor blade.

The invention is described in greater detail hereinafter with reference to the Figures in which:

Figure 1 shows a simplified view of a first embodiment of the apparatus according to the invention,

Figure 2 shows a side view of the apparatus according to the invention,

Figure 3 shows a second embodiment of the present invention,

Figure 4 shows a third embodiment of the present invention, and

Figure 5 shows a fourth embodiment of the present invention.

A carrier element 10 is provided in Figure 1. That carrier element 10 is of a rectangular shape. Provided at the centre of that carrier element 10 is a ball rotary joint 12. Even when the apparatus according to the invention is suspended rigidly, for example by being bolted to the roller head of a crane, that ball rotary joint permits a rotary movement of the entire apparatus about the vertical axis.

Provided opposite the carrier element 10 is a bottom element 16. The bottom element 16 is of substantially the same dimensions and shape as the carrier element 10. A side element 14 is provided between the carrier element 10 and the bottom element 16. Eyes 16 are shown on that side element 14. Cables can be passed through the eyes 26, which for example permit the entire apparatus to be rotated about its vertical axis, even when it has already been lifted by a crane.

The arrangement of the carrier element 10, the bottom element 16 and the side element 14 affords an open apparatus which in accordance with the invention receives the rotor blade. So that the apparatus encloses the rotor blade at four sides, there can be a further side element 18. That second side element 18 is however mounted pivotably by a hinge 22 to the carrier element 10. Therefore, the pivotal movement of that second side element 18 can open an opening through which the rotor blade can be received by or released from the apparatus.

So-called container corners 20 are also shown at predetermined positions of the carrier element 10 and the bottom element 16. Those container corners 20 permit the apparatus according to the invention to be connected on the one hand to further apparatuses of the same configuration and also for example during transport of a rotor blade to the transport vehicle, in a simple manner which is already known in the state of the art.

Just as for actuation of the second side element 18, a respective suitable drive can also be provided for actuation of the ball rotary joint 12.

It will be appreciated that, in the case of the ball rotary joint 12, that can be a drive motor while for example electrical, hydraulic or pneumatic devices can be used for actuation of the second side element 18.

Figure 2 shows a side view of an apparatus according to the invention with a rotor blade 29. Provided in this Figure within the apparatus according to the invention which is formed by the carrier element 10, the bottom plate 16, the first side wall 14 and the second side wall 18 which is mounted pivotably to the carrier element 10 are cushions 24 which on the one hand securely hold the rotor blade 29 in its predetermined position and on the other hand protect it from damage by the apparatus.

Those cushions 24 can be inflatable (with gas or liquid). In that way it is possible without any problem for the rotor blade 29 to be received by or released from the apparatus and the rotor blade 29 can nonetheless be held in a simple fashion. In that respect the cushions 24 can be inflated to a predeterminable pressure at which the rotor blade 29 is securely held but not damaged.

Figure 3 shows an alternative embodiment of the apparatus according to the invention. In this embodiment the carrier element 10 is smaller but it again has a ball rotary joint 12. It will be appreciated that in this case also a suitable drive can be provided at the ball rotary joint 12.

Longitudinal bearers 28 are arranged at two opposite sides of the carrier element 10. Mounted to those longitudinal bearers 28 once again at two opposite sides of the carrier element 10 is a rotor blade receiving means comprising upper elements 11, side elements 14 and bottom elements 16. Here the rotor blade receiving means is shown as being open at one side. It will be appreciated that it is also possible to provide there a pivotably mounted element which permits the rotor blade receiving means to be closed at the open side so that a rotor blade accommodated therein is again enclosed at all four sides. For the sake of clarity in this case also the container corners (see reference 20 in Figure 1) and the eyes (see reference 26 in Figure 1) are omitted.

This alternative embodiment of the apparatus according to the invention is of a lower inherent weight. In this arrangement however the individual elements are so designed that the strength involved is adequate.

Figure 4 shows a further embodiment of an apparatus according to the invention. This apparatus can be used to particular advantage in relation to rotor blades which have a through hole between the top side and the underside (that is to say the reduced-pressure side and the increased-pressure side in the case of rotor blades which act on the basis of the lift principle). In this embodiment of the invention the ball rotary joint 12 is again provided on the carrier element 10. Adjoining the carrier element 10 is a carrier bar 30 which is fixedly connected to the carrier element 10. A carrier plate 32 is provided at the end of the carrier bar 30, which is in opposite relationship to the carrier element 10. The carrier plate 32 is secured releasably to the carrier bar 30; the carrier bar 30 can therefore be passed through the through hole in the rotor blade, after removal of the carrier plate 32. Subsequently the carrier plate 32 is fixed to the end which is provided for same of the carrier bar 30 and thus clamps the rotor blade (not shown) in position.

As the carrier bar 30 can be passed in a particularly simple fashion through the through hole in the rotor blade (not shown) when a clearance fit is involved, but such clearance is unwanted during the transport operation, it is possible to provide on the carrier bar a variable portion 34, such as for example an inflatable bellows, which fills up the intermediate space between the carrier bar 30 and the rotor blade (not shown) and thus eliminates the play.

Figure 5 shows a further embodiment of an apparatus according to the invention. That apparatus again has a carrier element 10 with a ball rotary joint 12. In addition a carrier bar 30 is once again mounted to the carrier element 10 while the carrier plate 32 is again disposed at the opposite end thereof. It will be noted that, in this embodiment, the carrier bar 30 is connected to the carrier element 10 rotatably about the longitudinal axis of the carrier bar. In a central portion the carrier bar 30 also has a locking member 36.

There are many different possible options in regard to the configuration of the locking member 36. They include a fixed locking member which, after insertion into the rotor blade, is rotated together with the carrier bar 30 so that it engages into a corresponding opening provided within the rotor blade, and thus forms a releasable but firm connection to the rotor blade.

It will be appreciated that alternatively it is also possible to provide movable elements which are moved in situ into a locking position in order to form the connection between the rotor blade and the apparatus.